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ZOOLOGICAL SCIENCES IN THE FUTURE[1]

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I. INTRODUCTION

As far back as we can follow human records the relations of man and animals have been intimate. The Cro-Magnons in France of 50,000 or more years ago have left accurate and spirited records of animal groups, showing careful observation, that may have been born of the chase but which also displayed imaginative interest that extended beyond physical needs. Primitive man was largely dependent upon wild animal life for food and clothing. How far back the history of domestication of animals goes is still uncertain. The early use of totems and of animal names for families and clans testifies to a feeling of affinity. The satisfaction of needs, the stimulus to artistic impulse and the feeling of a kind of animal brotherhood created the first human understanding of animal life.

Aristotle, who so preeminently embodied the Greek feeling for natural law, is sometimes called the father of zoology, for he was the first great systematizer of animal lore, including not only that handed down, but also his own observations and reflections. He wrote a general "Historia Animalium," and also works on anatomy and physiology of animals, the famous "De Partibus Animalium," on the movements and locomotor organs of animals, "De Motu Animalium" and "De Incessu Animalium"; he wrote also to some extent on the behavior of animals, and all his philosophy is permeated by his zoological reasoning. Thus over 2,000 years ago the principal subdivisions, the philosophical implications and the social significance of zoology were delineated.

The evolution of zoology since may be traced in the enlargement of data, increase of accuracy in determination of facts accompanied by specialization, in the development of theories, in the application of techniques derived largely from other sciences, in economic

[1] Address before the American Association for the Advancement of Science in the conference on Science and Society, Ottawa, June 28, 1938.

and other human uses and in cultural development generally, both as donor and recipient.

The future of the zoological sciences must be founded on the course of their evolution up to the present. If we are to venture a guess as to where we are going, we must know the places at which we have arrived.

II. The Evolution of Zoological Theory

It is customary to divide the general theories of biology, which apply equally to botany and zoology, into those relating to the succession of organisms in time, the theory of organic evolution, those relating to their cellular structure, the cell theory and those relating to their physico-chemical constitution.

(1) *The Evolution Theory.* We shall not follow the history of the evolution theory. It is, as you know, since the publication of Darwin's "Origin of Species" in 1859 the basis for the development of the descriptive zoological disciplines: taxonomy, comparative anatomy, paleontology, embryology and geographical distribution. These studies reciprocally constitute and continually extend the evidence for organic evolution.

There is a strong tendency among zoologists at the present time, especially those devoted to experimental methods, to believe that these subjects have played their main role already in the development of zoology; and so in many places these fields of zoological education are neglected. The consequent failure, where such a situation exists, to appreciate the richness and interrelationships of animal life, the perfection of adaptations and the immensity of time in the geological ages that have gone into their creation is a grave defect in the education of the zoologist.

The basic descriptive disciplines of zoology are, moreover, live subjects for research. The rapid progress of paleontology, for instance, displays no features of senescence; one need only allude to the advance in mammalian paleontology and the extraordinary pictures it affords of adaptive radiation of orders and families or to the light thrown on human ancestry by discoveries of fossil human and sub-human remains. Comparative anatomy, descriptive embryology, taxonomy and geographical distribution require much more systematic work. Moreover, new view-points constantly appearing through experimental and analytic work demand reexamination and extension of the bases of observation, and it is necessary that experiment and observation proceed hand in hand.

Darwin's deepest interest, however, was not so much the demonstration that evolution is the method of origin of species and of adaptations, as the search for the causes of the evolutionary process. It was indeed the reasonableness of his theory of natural selection, or the survival of the fittest in the struggle for existence, that accounted for the rapid acceptance of the general theory. The selection theory aroused much interest as a matter of speculation during the latter part of the nineteenth century; but it has been only within the present century that an accelerating interest has developed in a statistical and experimental analysis of the subject. The progress of genetics, as is well known, is mainly responsible for this movement.[2] It is certain that factors of importance in the evolution process are being uncovered and appraised, in regard to the transmission of hereditary characters, the mechanisms of the action of genes in individual development and the consequences in the composition of populations. These topics belong to the division of the subject that Dobzhansky has aptly called micro-evolution, *i.e.,* evolution within experimentally available limits of time. Such investigations are still in their infancy, and as a first forecast I venture to predict a productive future for micro-evolution.

We think it reasonable to believe that the same causes operative throughout the whole period of evolution are operative to-day, and that it should therefore be possible to detect their presence experimentally. At the present time the theory of the gene enjoys a certain preeminence, for causes other than genetic affecting the heritable composition of individuals and populations have not been satisfactorily demonstrated in spite of much research. But it does not follow that the whole subject of micro-evolution is necessarily comprised within the theory of the gene.

It is difficult for the taxonomist and the paleontologist to believe that the gene theory is capable of explaining macro-evolution, the great trends covering geological ages; and the embryologist does not even attempt to use the gene theory in the analysis of the life history. Perhaps the solution of these difficulties may be met by some as yet unimagined extension of genetic theory, perhaps by some entirely different kind of discovery. But a gradual advance of understanding, rather than a quick solution, is to be anticipated in the theory of the causes of evolution, the most comprehensive of all scientific questions.

(2) *The Cell-Theory.* Since its establishment in 1838–39 by Schleiden and Schwann, the cell-theory has undergone a development that was unpredictably extensive and rapid. It led quickly to a complete rejuvenation of microscopical anatomy, physiology, pathology and embryology. To-day the cell still occupies its place as the unit of structure, function and development; no simpler unit has been discovered. All biological problems lead back to the cell; but we do not mean to assert either that they stop there or that cell-aggregates and composites may not display prop-

[2] The books of R. A. Fisher on "The Genetical Theory of Natural Selection" (1929) and of Theodosius Dobzhansky on "Genetics and the Origin of Species" (1937) are recent summaries of this movement.

erties unpredictable from those of the units. The cell has indeed become a sort of half-way house through which biological problems must pass, going or coming, before they complete their destiny. This being so, it is simpler to deal with this association in other connections.

(3) *The Theory of the Physico-Chemical Constitution of Organisms.* I hope that, since the decline of the mechanical view in physics has been so authoritatively announced,[3] the choice between being a mechanist or a vitalist in biology may soon cease to be regarded as the only alternatives. Biology is indeed committed to a thorough-going physico-chemical analysis of organic structure and function, but it is not committed to a reduction of its concepts to physico-chemical levels. Biology is an autonomous science in the sense that its problems concern the level of attainments, both historical and functional, of living organisms.

Evolution has not taken place in terms of increasing chemical or physical complexity, but in terms of organization. One has only to turn to the chemistry of the simplest organisms, best known perhaps for the bacillus of tuberculosis,[4] to realize that there is but little increase relatively in chemical complexity of organisms above this simple level, whatever stage of evolution may be examined. One may also say the same thing about the fundamental physical processes involved in the functioning of organisms. Students of biophysics turn by choice to single cells or microorganisms for material, and find that their results are applicable to the highest organisms.

That which characterizes organisms above all else is their anatomical and functional organization, and the regulations and correlations, both internal and external, which condition their wholeness and their capacity to survive in the struggle for existence through appropriate behavior.

The physical and chemical mechanisms, which we are increasingly learning to know, to understand and to apply in experiment, are to be regarded as mechanisms of control of structure and function on the biological level. Their rôle has not up to the present been shown to transcend this range. It is therefore fallacious to conclude that the organism is nothing more than a "physical-chemical-mechanical conglomerate."

When we attempt an analysis of biological organization, we must remain on the biological level. Hence the autonomy that we predicate for the biological sciences. It is true that the specifically biological factors are dependent on the "constancy of the physical units and physical modes of action," as R. S. Lillie has well said in a recent address,[5] but as he says further, they possess "a 'creative' side shown in a tendency to depart from routine and to produce novel action or organization," for which we have at present no physical analogy. The creative side is best shown in evolution, in individual development and in the course of experience, behavior and education.

It would be footless to inquire into the relative importance of research on the physico-chemical and biological levels, for both are necessary, and all physico-chemical analyses must be referred back to the organism as test-object or indicator. Many such investigations go astray or are incomplete because of an inadequate preceding biological analysis; and the reference back usually discloses a different or more complex biological situation than was postulated. The direction of biological research must thus always remain in the hands of the biologists and can not be assigned. But there will continue to be action and interaction between the sciences concerned.

The evolution of organisms as we know it is a historical process in terms of geological time. This statement, if fully apprehended, fairly poses the difficulty of a physico-chemical analysis of organization. What is more impressive than the duration of frail living matter, showing a stability far greater than the physiographic features of the earth's surface, unless it be the richness of its evolution within the period of its duration! These are the essential biological problems, and with respect to them the biological sciences are still in a period of early infancy.

III. The Development of Techniques

The history of the sciences may be presented primarily as a history of ideas; but there would be no such richness of ideas in science as we actually possess without richness of technique. I am sure that a very profitable philosophical treatise could be written about the relation of technique to ideas. Though tempted, I shall not essay to provide an outline for this treatise. Suffice it to say that in the present state of the scientific world, all techniques are available to the zoologist: mathematical, chemical and physical. A single old example may serve to place the interrelation of technique to ideas before us.

Following the earliest anatomical techniques, the first great technique that fashioned the zoological sciences was that of magnification, the invention of the compound microscope about the end of the sixteenth century and its subsequent development. A new world of life was discovered in the latter part of the seventeenth century: protozoa, bacteria, spermatozoa and

[3] Einstein and Infeld, "The Evolution of Physics," Simon and Schuster, New York, 1938.

[4] H. G. Wells and Esmond R. Long, "The Chemistry of Tuberculosis," The Williams and Wilkins Co., Baltimore, 1932.

[5] Ralph S. Lillie, "The Nature of Organizing Action," *Am. Nat.*, 1938.

tissue elements; and ideas ran riot as a consequence in the eighteenth century. The subsidiary techniques that have developed, of sectioning, staining, etc., fill volumes. That curiosity of the opticians in the seventeenth and eighteenth centuries remade biology, a fact worth mentioning because it is so commonplace as to emphasize very emphatically the dependence of science upon technique.

We could not have modern biology without mathematical, chemical and physical techniques. In general, the techniques of the higher, or more complex, sciences tend to be derived from those of the simpler sciences, and this in itself promotes conceptual resemblances, as fruitful associations always do. But when technique outruns ideas, we tend to have a relatively sterile association. It should not be held that on account of its dependence on physical and chemical techniques, biology is reducible to physics and chemistry. This would be an overestimate of the rôle of technique in the progress of ideas.

Ideas proceed from felt needs, material or intellectual, and they are acted out through the scientific method by techniques, the results of which in their turn produce the discovery of new opportunities for advance, and hence the feeling of new needs; there follow new ideas and new techniques or applications of techniques. It is a circular process. The discovery of x-rays was not immediately related to the problem of cancer; but when the connection between the application of x-rays and the retardation of cancerous growth was discovered, what a host of new ideas arose in the biological field, and how important the whole subject of radiant energy in relation to the organism has become!

Among fruitful conceptual resemblances in zoology to the simpler sciences are the experimental method in general and the use of mathematical language and tools. Certainly the method of experiment as contrasted with direct observation was developed earlier and more completely in the physical than in the biological sciences. Its application in certain of the zoological sciences, *e.g.*, embryology and behavior, lies within my own life-span, and as yet experiment has barely entered the taxonomic field.

Experiment and mathematical analysis are bound to play an increasing rôle in the progress of zoology. The prospects for productiveness of such procedures imply a sharp definition of data and of units; otherwise deductions are faulty or we are left with empty formulae. The rôle of intelligent and accurate observation as basis for experimental and mathematical treatment will always be crucial. The fact that this requirement has not always been met is merely a sign of immaturity of the subject and not any indication of limits. The attempt to create a mathematical biophysics that will play a rôle of prediction and suggestion, as does mathematical physics, is in the spirit of the times; and the endeavor to apply the principles of modern field-physics to problems of biological organization is promising.[6]

We can not predict what the next great technical advances in the study of zoology may be, but we confidently expect that there will be such; and the results may even be revolutionary. We are, however, far from complete utilization of the possible techniques that recent advances in physics and chemistry have placed in our hands; and it will be a long time before we have exhausted these possibilities.

IV. Zoology and Cultural Development

Sciences develop not only in the realms of ideas and techniques, but also in a changing social and cultural environment, and these necessarily interact. Though strictly inseparable, there is an attempt to estimate separately the influence of science upon society and the impact of society upon science. At the present time the estimates largely concern the influence of science upon society. It is regarded on the one hand as "the living source of all progress" and the basis of intellectual freedom, or on the other as a "Frankenstein monster that will slay its own master."[7] Moulton, from whose citations in the introductory address to the present series of conferences I take these estimates, ventures the remark, "Perhaps the way forward lies in a great extension of the scientific spirit."

Dr. Moulton presumably means an extension of the scientific spirit and its methods beyond the field of the natural sciences, in which its native home is established, into the fields of social phenomena. The scientific spirit consists, as Dr. Moulton also says, in deriving conclusions from facts. This no doubt means as distinguished from the drawing of conclusions from *a priori* principles, such as those enunciated in the preamble to the Declaration of Independence, or, let us say, in the "Wealth of Nations." In operation, this requires knowledge of the ways of ascertaining facts, and of distinguishing and using those that are significant. When fact and principle are in disagreement, it is the principle that must yield and submit to modification. If this be admitted, it emphasizes that being certain of our facts is a tremendous responsibility, which rises in proportion to the status and significance of the principle controverted. There can surely be no valid objection to the extension of such method in the social sciences.

We are accustomed in our free society to hold that the development of all science is good; in certain coun-

[6] Burr and Northrop, *Quar. Rev. of Biology*, 10, 1935.
[7] H. G. Moulton, SCIENCE, 1938.

tries less free it is ruled that only those aspects of science that contribute to their special national ideologies are good. But there is agreement on the thesis that in science is power. A free society in a world containing societies that are not free could neglect science only at its peril; and they also may suffer peril who neglect or distort part of it.

The scientific world as a whole has always, to the best of its ability, asserted freedom on its own behalf in research and in teaching; and conversely, has been willing to grant freedom to others. It has thus been a strong influence for democracy. It has often had to fight its way. In the zoological sciences the battle for evolution that so stirred the world in the latter part of the nineteenth century occasionally needs to be fought again, as in the famous trial in Tennessee a few years ago. Freedom in animal experimentation is periodically assailed, threatening the fight against disease; restrictions are placed on the teaching of the facts concerning human reproduction. In other countries than ours, free teaching of the principles of heredity, especially in its human aspects, is impeded. It should not be forgotten that freedom is never permanently attained; it may be won, but requires always to be defended.

The democratic assumption that all science is good does not mean that all that is good is science. It is impossible to say what a society wholly devoted to science would be like, for we have never had such a society on any national scale; but certainly the love of truth and freedom that characterizes science, and the training of the imaginative qualities demanded, would favor all that is best in literature, art, music, philosophy and religion.

Apart from such general considerations, we must deal with the very complex question concerning the part that the zoological sciences play in the welfare of mankind. This confronts us immediately with the problem of determining what, for our purposes, should be considered as zoological sciences. There is no such problem on the side of botany, for everything concerning plant life is included; but man unfortunately belongs in the zoological system, and yet the development of man is specifically reserved to the fifth conference, and this is only the second! It happens also that man is the most interesting zoological species, and that students of man and his needs have systematically picked out of the zoological sciences all that is most interesting to them; nor do they stop here, for they also pick out promising zoologists and graft them on to their own departments of anatomy, embryology, physiology, bacteriology and parasitology, vital statistics, entomology, animal husbandry, fisheries, forestry, etc. Zoologists also cooperate in the work of clinical medical departments in various places. This is in itself sufficient evidence of the human interest and value of zoology and, I hope, sufficient excuse if the boundaries of the present conference should be overstepped.

It is especially difficult to define in a few words the relationship of the zoological sciences to medicine. All advanced medical schools require general zoology, comparative anatomy of vertebrates and embryology as an introduction to the conventional medical courses. Anatomy and physiology are usually organized as departments distinct from zoology, but they overlap and are frequently manned to a considerable extent by zoologists of special interests and training; the same thing may be said of bacteriology, with which the zoological discipline of parasitology is frequently united. Such relationships have developed very rapidly in the modern period of scientific medicine, and it is safe to predict that this tendency has not run its full course. Direct relationships of clinical medicine with zoology are also found: for instance, application of results in the field of physiology of reproduction to obstetrics and in the increasing attention to the application of the principles of genetics to hereditary diseases and diatheses.

The economic uses of zoology are very important. Consider, for instance, the control of insect pests: in 1915 it was estimated that in the United States they caused an annual money loss of over $1,212,000,000 to cereals, hay and forage, cotton, tobacco, sugar, fruits, forests, animal products, products in storage, etc. This estimate has recently been raised to about $3,000,000,000. Whether more or less, the damage is very great. The federal and state governments employ large staffs of entomologists engaged in the study and control of these pests. The study and control of parasitic worms, liver flukes, tapeworms, trichinae, hookworms, filariae, etc., engage the attention of numerous other zoologists within and without the government services. Fisheries industries employ many zoologists; shellfish industries likewise. The regulation of the fur seal industry is based on studies of a zoological commission.[8] Such subjects as the fouling of ships' bottoms and destruction of marine structures by boring mollusks likewise come to the zoologist for study and advice. This is a very incomplete list of the economic uses of zoology.

V. Zoological Sciences in the Future

There are approximately 850,000 species of animals already described; the number may easily run up to 1,000,000 before the descriptive labors of the taxonomists are through. This is a relatively simple and safe prediction.

But I take it that we are mainly interested in general theory and social effects. For these purposes it

[8] *Bull.*, U. S. Bureau of Fisheries, 1914.

is simplest to assume the most favorable social and political conditions for the continued evolution of the zoological sciences, leaving the evolution of social environments themselves to the subsequent conferences.

The most general trends that we have already noticed are a steady progress in the application of the methods of experiment to zoological problems and a rising state of consciousness of social, as contrasted with merely intellectual, responsibility. The background is occupied by the descriptive and systematic observational disciplines, which need and continue to receive constant attention, if only in the service of experimental investigations which require increasingly exact observational bases.

It has been argued that biology, especially animal biology, holds more for the improvement of conditions of living than the physical sciences. Some even go so far as to say that we need no more "gadgets of civilization" of a physical kind, and hence should center our efforts in science on the organism for the sake of which "gadgets" are designed, man himself. The organism *is* in a way more significant than its environment and should be equal to its opportunities. It is unfortunately true that many humans are poorly equipped, biologically or economically, to make the best avail of the resources of civilization, and so long as this is true it constitutes a good argument for special attention to the biological and the social sciences. However, the interdependence of the sciences would render it hazardous to neglect the inorganic sciences for the sake of the sciences of the living, and any such attempt would probably defeat its own ends.

The advance of the zoological sciences requires enlarging support for the advancing technologies and for access to properly controlled materials. The best materials for experiment are not to be found everywhere. In the progress of development of experimental zoology, university and other laboratories have been forced to make provision for the maintenance and breeding of animals and in some cases to establish farms for these purposes. The great importance of marine animals for experimental work has favored the development of marine laboratories, which in some cases have become national and international centers for study. At the Marine Biological Laboratory at Woods Hole, Massachusetts, over 350 investigators gather in the summer, representing about 110 American universities and laboratories, and approximately 10 foreign institutions. There the workers are supplied with the living material they require and facilities for keeping it in good condition, with a great variety of chemical and physical supplies and apparatus, with access to a very excellent working library, and living accommodations. The effect of this institution upon the progress of zoology and general physiology in America during the period of fifty years has been very great. A variety of favorable influences have radiated from it. The maintenance of such institutions along our coasts is needed to provide the conditions under which the zoological sciences may prosper. Stations at other points in the interior, on the lakes, great and small, in the mountains and other special ecological territories, are now doing good work and should be supported. The zoological sciences require such special provisions.

When a problem is discovered and accurately defined by observation, experiment is then the method *par excellence* for deeper understanding of the mechanisms of control in which we are interested; and so zoology has tended more and more in the last half century to become an experimental science. The modern zoological laboratory must be provided with means for maintaining and breeding different kinds of animals; and, for experimenting with them, a great variety of chemical and physical facilities must be available. The principal divisions of experimental zoology—genetics, experimental embryology, ecology and behavior and cellular physiology—depend for their progress on such provisions.

No single speaker is able to do justice to the whole field of experimental zoology nor would there be time for a systematic survey. In a necessarily preferential selection, one must follow his own interests in illustrating the possibilities and the limits of prediction.

From about 1915 to 1920 I was interested in a purely zoological problem, *viz.*, the fact that a female calf born twin to a bull calf was sterile in about 90 per cent. of the cases, and was, as a matter of fact, in its internal anatomy in such cases predominantly male. This phenomenon had long been known, and in some remote period of English history the sterile females had been denominated free-martins. Embryological analysis showed that in all such cases the circulations of the twins were joined in early fetal life and that each individual continued to receive blood from the other until birth. The inference that the malformation of the female was due to influence of its brother's blood was inescapable, and inasmuch as the malformation primarily concerned the reproductive system it seemed probable that it was due to a sex-hormone secreted by the male.

This led to other investigations and to a request from the Sex Research Committee of the National Research Council in 1922 to present a program of investigation in the biology of sex. Among other topics, I presented that of the sex hormones. Nothing was known at that time of the chemical nature of the substances, the existence of which was postulated on certain influences of the gonads transmitted through the circulating blood. I wrote at that time: "It will be the province of the

chemist to endeavor to identify, isolate and ultimately synthesize the sex hormones. The possibility of an ultimate ready control of sex characters and behavior within the limits discovered to be possible by the biologist must depend on the chemist working in close cooperation with the biologist."

About this time, owing to other discoveries, events began to move very rapidly; the first real discoveries on the chemistry of the female and male sex hormones were made in St. Louis and in Chicago within a year or two. As there is no copyright on ideas in science, the investigations spread to Germany, Holland, Switzerland, England, Scandinavia and other countries, also to numerous centers in America; various unforeseen lines of work developed from it. The sex hormones themselves were gradually purified and obtained in pure crystalline form in 1929; then synthesized, modified in various ways, used in extraordinary animal experiments, and their clinical utilization is being explored. The relationships with carcinogenic compounds is now being tested among other things, and the subject is leading into quite unexpected fields.

Thus a program involving a prediction that I never expected to see finished in my lifetime was brought to completion, as far as stated, within a period of less than fifteen years; and as always happens, the unexpected has also emerged and the way ahead opened up.

I mention this from my own experience to illustrate the possibility of short-term predictions. Every program of investigation involves the principle of prediction, because after preliminary observation and preparation it starts out from an hypothesis—"either, or"; advance is through a series of subsidiary hypotheses. Every investigator tends to favor "either" or "or" if he starts out with a prepared mind; but, if he be a good investigator, he abides loyally by the result and learns from it. So it would be possible to present an almost unlimited series of short-term predictions.

Long-term predictions can concern only very general trends, and they lose in probability as they concern specific questions. To illustrate: following the example I have already chosen, there can be no reasonable doubt that our knowledge of the gonadal and hypophyseal hormones will grow rapidly, including their chemical synthesis in some additional cases at least, and hence ready availability; in such cases the production of allied chemical compounds by well-established principles, the testing of the physiological effects of such compounds, and so on. But what the effect of such increase of knowledge may be on regulation of sex ratios, on control of the reproductive cycles, on the physiology of pregnancy, and the radiating effect on social customs and development, it is impossible to foresee. The effects certainly will be important.

Zoology, in the more conventional sense, will in my opinion continue to occupy a privileged position with reference to fundamental and long-time programs of research. It is the only one of the sciences of animal biology not directly attached to programs of immediate social significance, and that is not more or less confined and restricted by such relations. It still has its place in the academic field, as contrasted with the professional fields. It is important that this place be preserved and that free rein be given to the imaginative faculty and the development of theory. We may venture to predict that under these circumstances in the future, as in the past, conceptions of social significance will continue to emerge.

The zoologist should know the wealth of animal life for its suggestiveness and for the opportunities, often unique in specific animal forms, for successful experiment. In the course of the age-long struggle for existence, nature has discovered the mechanisms most apt for each species to meet the conditions of survival. These methods are often different for the same problem in different species, sometimes apparently quite radically different. The animal kingdom is a great storehouse of information concerning ways to solve animal and human problems, which we have only begun to explore.

When any fundamental discovery is made in the zoological sciences, no matter where—*e.g.*, parthenogenesis in sea-urchins, heredity and its relation to chromosomes in the fruit-fly, embryonic organizers in salamanders, the hydrogen ion concentration in slime moulds, sea-urchin or frog eggs, colloidal properties of protoplasm anywhere, permeability of cell-membranes in plants and animals, the independent life of cells in tissue culture or of organs under suitable conditions, balance of salts required by marine eggs or the frog's heart, electrical properties of nerves in frogs or squid, and so on indefinitely—there is repercussion throughout the entire realm of the biological sciences, and especially in the complex of zoological sciences that we call medicine, so alive now to everything that may affect the well-being of the human individual.

Essentially new discoveries proceed in the long run from fundamental research conceived in intellectual terms. The social use will eventually appear, and organization for its exploitation is sure to be effected by various interested agencies. There should be large provision for free research. There is a real danger to the progress of the zoological sciences in placing too much emphasis on economically or socially useful types of investigation; and there is already a pronounced tendency in that direction, even in our universities, by the relative ease of securing funds for such research, thus diverting the talents of investigators away from

more fundamental work. Granted that a sharp line can not be drawn and that economically motivated research may lead into problems of fundamental theoretical significance, nevertheless free research constitutes the greatest long-term asset of society in the field of science.

It is more than a little illogical for society to hold on the one hand that the results of science, developed under a system of freedom of research for which it has been necessary constantly to fight, constitute the greatest economic asset of nations, and on the other hand to maintain that science will do better in the future if its direction is taken over by social agencies. The problem of social agencies is not so much to direct the course of science as to make good use of its results.

Lest I may seem to be deprecating organized research let me say that this is not in the least my intention, nor has it been my past example. Organization of research has increasing importance, illustrated by so many productive examples as to require no defense. It has existed as long as our universities, academies and scientific associations and societies. It has been strengthened more recently by industries, technical schools and governments. Almost every scientific man is as a matter of course a member of one or many such organizations. I am, however, much concerned about the auspices of the organization of research and the freedom of the members of such organizations. Most scientific men work best in an organized program. This, I think, has to be recognized. But there is food for thought in a remark once made to me jokingly by one of the best-known American physicists, now dead: "I propose," he said, "to organize a Committee of One Hundred to write the best American poem." The limitations of organization for creative work are thus suggested.

In some cases the results of science in our own time are not yet put to their full social uses; there is an inevitable social lag or even active social resistance. A good example of retardation due to social resistance, now in the course of breaking down, is the present campaign against syphilis. Ever since the discovery of the causative organism (*Treponema pallidum*) by a zoologist, Schaudinn, in 1905, the way was open to its control, which was realized, through the pioneer work of Ehrlich on the chemo-therapy of arsenic compounds, by a whole host of investigators; but it has remained for the years 1937–38 to inaugurate an effective campaign for the suppression of this destructive disease in our own country.

In other cases groups of people organize to promote applications of biology to the social organism when both biological and sociological opinion is divided. The most striking example is in the field of eugenics, the improvement of the inborn qualities of the population. Biological opinion is divided because our knowledge of human heredity is quite rudimentary as compared, for instance, with our knowledge of heredity in fruit-flies or guinea pigs. Even if we felt sure that our knowledge of the principles of heredity in lower animals is theoretically fully applicable to mankind, we would not know how to apply it energetically except in most general terms, for there are no pure lines in human inheritance for one thing, and for another, we have few animal analogies to the human qualities of character that we most need in the social process. Biological opinion is divided even on the subject of negative eugenics, the elimination of the unfit, not so much on the general desirability of the principle as on the definition of unfitness, the determination of standards and the methods to be employed. Sociological and political opinion is also divided sharply, on the question of the trends of existing social, economic and political selective processes as they affect population, and the desirability of applying such a sharp instrument as radical eugenics to society before the possibilities of social amelioration in other ways are more fully explored. Under these conditions we should have institutes specially devoted to human genetics for the sake of the medical as well as of the social problems involved.

One sometimes feels tempted to despair of the social coordination of scientific knowledge for the increase of the well-being and happiness of mankind. But faith in the progressive evolution of mankind is stronger, in the scientific world at least. I have the conviction that the ethical principles of Christianity are wide-spread among the masses of mankind and that they will prevail. But the processes of evolution are slow, and we may have to wait a long time.

OBITUARY

HENRY HERBERT DONALDSON

HENRY H. DONALDSON was born at Yonkers, New York, on May 12, 1857, and died at his home in Philadelphia on January 23, 1938. He prepared for college at Phillips Academy, Andover, Mass., and graduated from Yale in 1879 with the degree of B.A. The following year he did advanced work at Sheffield Scientific School and conducted research with Professor Russell H. Chittenden "On the Detection and Determination of Arsenic in Organic Compounds"; this was published jointly with Professor Chittenden as his first scientific paper. During the year 1880–81,

he attended the College of Physicians and Surgeons in New York and devoted especial attention to human anatomy. Realizing that his interests were in research rather than in medicine, he entered the Graduate School of Johns Hopkins University in 1881 and was appointed fellow in biology and reappointed the following year. During these years he specialized in physiology under Professor H. Newell Martin and as a result of this work published, between 1882 and 1886, four papers on physiology and pharmacology (two of them jointly with other students).

After his two years as fellow he was appointed assistant in biology for the year 1883–84 and began his thesis for the doctor's degree under G. Stanley Hall, who was at that time professor of psychology at Johns Hopkins. His thesis "On the Temperature Sense" dealt with the mapping of heat-sensitive and cold-sensitive areas of the skin and was published in *Mind* in 1885, in which year he received the degree of Ph.D. The following year he published jointly with Professor Hall in the same journal on "Motor Sensations of the Skin."

This work led him to seek more extensive training in neurology in European centers and in 1886–87 he studied under von Gudden, Forel, Golgi and others. At the close of this year abroad, he was appointed associate in psychology at Johns Hopkins and held that position from 1887 to 1889. In the meantime G. Stanley Hall had become president and professor of psychology in the newly founded Clark University at Worcester, Mass., and in 1889 Dr. Donaldson was called to Clark as assistant professor of neurology.

His proven ability in this field led President Hall to assign to him for study the brain of Laura Bridgman, a blind deaf-mute who had been taught to speak and had attained notable mental development. The results of this study were published in two papers in the *American Journal of Psychology* in 1891 and 1892. In a brief autobiographical note written many years later Dr. Donaldson said: "The chief modifications found in this brain were caused by an arrest of growth due to the destruction of the sense organs. This made it desirable to know the developmental state of the brain at the time of the destructive illness (two years). Such information was not in the literature. With the hope of contributing to fill this gap, I arranged a program for the study of the brain (nervous system) from birth to maturity. In carrying out this plan quantitative methods were used and data on the size and weights of the parts and on the number of cells in them were especially considered."

This led to that long, accurate, quantitative study of growth which was the main theme of his life work. At the beginning of this work, he gathered together all the available records on the growth of the central nervous system and published them in a book entitled "The Growth of the Brain" (Scribner's, 1895).

He remained at Clark University until 1892 when he joined the migration of most of the faculty to the new University of Chicago, where he became professor of neurology. He was very active in the development of the scientific departments, being dean of the Ogden School of Science from 1892 to 1898. A serious illness interrupted his work about this time and left him permanently lame, but he returned to his work with courage and determination and from 1898 until his death there was never a year when he did not publish one or more papers.

In 1905, ten professors of anatomy and zoology in leading universities were invited to serve on the Scientific Advisory Board of the Wistar Institute in Philadelphia; among these was Dr. Donaldson. On the invitation of General Wistar, founder of the institute, the advisory board met in April, 1905, and was asked to propose a plan for the future development of the institute. It was the unanimous opinion of the board that the institute should be devoted primarily to research, and in the beginning to research in neurology. This met the hearty approval of General Wistar, and the board was asked to recommend some one to organize this work. Dr. Donaldson was the unanimous choice of all the other members and after careful consideration he accepted the position of professor of neurology and director of research in the Wistar Institute, and in 1906 transferred his work and his chief associate, Dr. S. Hatai, from Chicago to Philadelphia.

While at Chicago, Dr. Hatai had published fifteen papers based on the white rat and Dr. Donaldson had concluded that it was the best available mammal for laboratory work on problems of growth. However, for accurate, quantitative studies it was necessary to establish a uniform stock, with individual differences reduced as much as possible. Accordingly, he and his associates set about the task of producing a standardized strain of albino rats. How well they succeeded is recognized throughout the world in the use of the Wistar Institute rats in the most accurate scientific work. This work was summarized in a book entitled, "The Rat: Reference Tables and Data," 1915. A revised and enlarged edition was published in 1924.

Much of Donaldson's work was on the growth of the nervous system, but it was extended to include muscles, viscera, skeleton and teeth under normal and experimental conditions. In addition to several papers on the number and size of the nerve cells and fibers, there were others on the effects of exercise, feeding, castration and age on the size and weight of particular organs. The determination of the percentage of water

in the nervous system under all the experimental conditions named constituted a large section of his work.

Altogether he personally published nearly one hundred papers and monographs, and his students and associates published more than three hundred and sixty. His method of directing research work was well described in his published report in 1925 to the Scientific Advisory Board of the Wistar Institute: "No investigator is ever asked to do anything which is not for his individual and scientific welfare. . . . In every case the investigators receive full personal credit for their work. This is as it should be for it is the virtue of academic laboratories that the emphasis is put on the individual rather than on the institution." Among those who published work from his laboratory were some thirty Americans, twenty Japanese and a smaller number of other nationalities. Many of these persons are leaders in their professions and all of them revere his memory.

He received the honorary degree of Sc.D. from Yale in 1906 and from Clark in 1937. He was president of the Association of American Anatomists (1916–18), of the American Society of Naturalists (1927) and of the American Neurological Association (1937). He was a councilor of the American Philosophical Society for four terms of three years each between 1911 and 1936, chairman of its Publication Committee from 1932 and vice-president from 1935 until his death. He was a member of the Corporation of the Marine Biological Laboratory from its organization in 1888 and a trustee from 1912 until his death. He was elected to the National Academy of Sciences in 1914 and was a member of its council in 1919. He was also an honored member of ten other American and foreign scientific societies.

On his eightieth birthday (1937), a bronze portrait medallion of him, made by Dr. R. Tait McKenzie, was placed with suitable ceremonies in the Lenape Club at the University of Pennsylvania, of which he had been president for twenty years. A replica of this medallion hangs in the hall of the American Philosophical Society. On the seventy-fifth anniversary of his birth, May 12, 1932, a special anniversary volume of the *Journal of Comparative Neurology* was dedicated to him. It was preceded by an admirable portrait and contained a brief sketch of his distinguished career, followed by twenty scientific contributions from associates and friends and the following affectionate testimonial: "He has won esteem and affection of the Editorial Board by unfailing courtesy, loyal friendship and generous support of all worthy enterprises. For his cordial and invaluable cooperation and wise counsel during nearly thirty-five years the *Journal of Comparative Neurology* owes him much."

Perhaps his most distinctive personal trait was that quality which Sir William Osler celebrates in his essay, *"Equinimitas."* With this were naturally associated orderliness, persistence, serenity. His laboratory and library were always in perfect order, his comings and goings were as timely as the clock, he never seemed hurried and yet he worked *"Ohne Hast, ohne Rast."* His sympathies were broad and deep and even his closest friends never learned from him of his generous contributions and acts of kindness to those who were in need. His students and colleagues knew him as a man of infinite patience, even temper and great nobility of character, and they loved and honored him.

In 1884, he married Julia Desboro Vaux, of New York, who died in 1904. Two children were born to them, John C. Donaldson, now professor of anatomy in the Medical School of the University of Pittsburgh, and Norman V. Donaldson, sales manager of the Yale University Press. In 1907, Dr. Donaldson married Emma Brace, of New York, and their hospitable homes in Philadelphia and Woods Hole are known to a host of loving friends.

After his long illness in the middle nineties of the last century, he was never in robust health but was almost never incapacitated for work. Until a few days before his death he was at work as usual in his laboratory at the institute. His end came as a result of pneumonia and heart failure. With characteristic foresight, he and Mrs. Donaldson had planned the simple and appropriate funeral service which should be held in the event of the death of either. His pallbearers were selected from among his scientific associates and the officers of the institute, the University of Pennsylvania and the American Philosophical Society. His brain was preserved and added to the notable collection of the Wistar Institute and his body was cremated. His work, influence and memory remain to make the world richer for his having lived in it.

EDWIN G. CONKLIN

RECENT DEATHS

DR. RAYMOND L. BARNEY, professor of biology at Middlebury College, Vermont, died on July 9 at the age of forty-six years. Dr. Barney had been a member of the department of biology at the college since 1924. He served as acting dean in 1936.

DR. EDWARD FULLER BIGELOW, president of the Agassiz Association, editor of the monthly magazine *A Guide to Nature* and curator of the Bruce Museum at Greenwich, Conn., died on July 13 at the age of seventy-eight years.

PROFESSOR FERNANDO NEVERMANN, *since 1909 professor* of entomology at the National Agricultural School at San Jose, Costa Rica, was recently accidentally killed while searching for ants that had been damaging banana plants.

DR. CHARLES EDOUARD GUILLAUME, *since 1915 director of the International Bureau of Weights and* Measures in Paris, has died.

THE death is announced of Dr. Hugo Hergesell, professor of geophysics and meteorology; of Dr. Walther Vogel, professor of historical geology, and of Dr. Konrad Theodor Preuss, director of the Museum of Folk Lore, all of Berlin.

SCIENTIFIC EVENTS

THE POULTRY RESEARCH LABORATORY AT EAST LANSING, MICHIGAN

CONSTRUCTION of the regional poultry research laboratory at East Lansing, Mich., is expected to be under way by August 1, according to a report issued by Dr. J. R. Mohler, chief of the Bureau of Animal Industry, of the U. S. Department of Agriculture.

The contract calls for the construction of a central laboratory building, two large brooder houses and two smaller buildings for special disease studies. The buildings should be completed by January 1, 1939. The unit will be located on a site of 50 acres recently deeded to the government by Michigan State College for this purpose. The site is one mile south of the college.

Twenty-five north central and northeastern states will cooperate with the department in the laboratory work. The states are Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, Oklahoma, South Dakota, Wisconsin, Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont and West Virginia.

Selection of a director and other staff members will be made through a regularly announced Civil Service examination. As soon as the buildings are completed, work will begin on the development of effective control methods for fowl paralysis, a disease that is prevalent on both commercial poultry farms and diversified farms. It is estimated that losses from poultry diseases cost producers nearly a hundred million dollars annually in the states cooperating in the research. Approximately half this amount, it is estimated, is due to fowl paralysis.

Dr. Mohler points out that there is no adequate knowledge concerning fowl paralysis, and no effective means are known for its control. Laboratory workers will concentrate on a search for the causative agent and will attempt to determine to what extent breeding for resistance to the disease can be successful. Related projects dealing with the effects of parasitism nutrition practices and different management practices on the spread of disease will be undertaken as rapidly as possible.

THE AVERY EXPEDITIONS OF THE FIELD MUSEUM

THROUGH the generosity of Sewell Avery, a trustee of Field Museum, funds have been provided for sending four expeditions into the field during 1938.

The first of these left Chicago on June 18 to collect specimens for use in physical geology exhibits. Work is under way in northern Colorado, and later activities will be transferred to New York, Connecticut, Massachusetts, Rhode Island and possibly other eastern states. This expedition is being conducted by Sharat K. Roy, curator of geology, and is a continuance of the field work of this type in which he was engaged last year.

On July 15, John R. Millar, curator of the N. W. Harris Public School Extension, left for Nova Scotia, where he will make studies and collect material for the department of botany (of whose staff he was formerly a member). The prime object is material for an exhibit representing the submerged vegetation of the northern Atlantic waters. Owing to the extreme tidal conditions prevailing in the Bay of Fundy, where the difference between high and low water levels reaches as much as fifty feet, it is expected that this will prove to be an exceptionally favorable locality for collecting kelps and other marine plants.

Early in September, Emmet R. Blake, assistant curator of birds, will sail for British Guiana. At Georgetown he will charter an airplane to take him and two native assistants 600 miles inland to the headwaters of the Corentyne River, on the southernmost boundary of the country, close to the frontiers of Dutch Guiana and northern Brazil. This region, entirely uninhabited by human beings, is almost totally inaccessible except by air. At certain seasons it may be reached by river travel with special boats manned by large crews. The water trip, however, requires about five weeks, whereas by airplane it may be made in four hours. The area has never been worked before from a biological standpoint, and Mr. Blake will seek a representative collection of its vertebrates, including birds, mammals, reptiles and fishes. The airplane will return to its coastal base leaving Mr. Blake entirely out of contact with the outside world for about four

months, except for one or two return flights to deliver supplies.

A botanical expedition to Guatemala will be conducted by Paul C. Standley, curator of the herbarium, who will leave Chicago about the beginning of November. It is planned to spend approximately five months in the field, gathering herbarium material, for use in preparation of a flora of Guatemala, similar to that of Costa Rica, which is now in course of publication. Guatemala's vegetation is more varied in type than that of any other Central American country, although not so rich in species as that of Costa Rica.

THE WARSAW CONFERENCE ON MODERN PHYSICS

A CONFERENCE on the new theories in modern physics was held in Warsaw from May 29 to June 2 on the proposal of Professor Bialobrzeski, of the University J. Pilsudski, member of the International Committee of Intellectual Cooperation. It was organized by the International Institute with the help of the Polish Government and the Polish Committee of Intellectual Cooperation. Scientific men from various parts of the world attended the meeting and several reports were discussed which will be shortly published by the institute.

The complete list of participants follows: C. Bialobrzeski, the University J. Pilsudski; E. Bauer, the Collège de France; Niels Bohr, the University of Copenhagen; L. Brillouin, Collège de France; L. de Bröglie, the University of Paris; C. Darwin, the University of Cambridge; Sir Arthur Eddington, the University of Cambridge; R. H. Fowler, the University of Cambridge; G. Gamow, the George Washington University; S. Goudsmit, Princeton University; E. Hylleraas, University of Oslo; O. Klein, University of Stockholm; H. A. Kramers, the University of Leyden; L. de Kronig, University of Groningen; P. Langevin, Collège de France; Ch. Moeller, the University of Copenhagen; J. von Neumann, Princeton University; F. Perrin, the University of Paris, L. Rosenfeld, the University of Liége; W. Rubinowicz, the Jean Casimir University at Lwow; S. Szczeniowski, the Etienne Batory University at Wilno; J. Weissenhof, the Jagellonne University at Krakow; L. Wertenstein, the Free University of Warsaw; E. P. Wigner, Princeton University; F. J. Wisniewski, the Polytechnic School of Warsaw.

The following reports were presented and discussed:

(1) The necessity of the indeterminist interpretation of the formal structure of the quantic mechanics; value of the proof of indeterminism, J. v. Neumann; objections against the complete character of the theory of quanta; process of measurement as a *sui generis* phenomenon having an indeterminist character, Professor Niels Bohr.

(2) Questions concerning the relations between the quantic mechanics and the theory of relativity, Professor L. de Bröglie.

(3) Limits of the applicability of the present system of theoretical physics (nature of the elementary particles, action of the particles of great energy). Difficulties in what concerns the quantic theory of the electromagnetic field, Professor Kramers.

(4) Problem of the individuality of elementary particles and its relation to quantic statistics and the postulate of Pauli, Professor L. Brillouin.

(5) Cosmological applications of the theory of quanta, Professor Sir Arthur Eddington.

(6) The positivist and realist currents in the philosophy in physics, Professor Langevin.

Apart from the scientific work of the conference, a number of excursions were organized to Krakow and Zakopane.

THE ASHEVILLE MEETING OF THE FISHERIES AND CONSERVATION SOCIETIES

REPRESENTATIVES of forty-six states attended the combined meetings of the International Association of Game, Fish and Conservation Commissioners, the American Fisheries Society and the National Planning Council of Commercial and Game Fish Commissioners held at Asheville, N. C., during the week of June 20. June 20 and 21 were devoted to the convention of the International Association, June 22 to the annual meeting of the National Planning Council, and June 23 and 24 to the sessions of the American Fisheries Society. Saturday was reserved for a field trip to the Pisgah National Game Preserve to inspect the cooperative trout rearing station maintained by the United States Bureau of Fisheries, and Forest Service demonstrations of stream improvement work, fish cultural and fawn rearing activities.

Arthur L. Clarke, superintendent of fisheries of the Missouri Fish and Game Department, was elected president of the International Association to succeed Frank B. O'Connell. Other officers of the association include J. D. Chalk and Seth Gordon as first and second vice-presidents; R. P. Holland, secretary-treasurer, and Talbott Denmead, general counsel.

The morning session of the meeting of the National Planning Council of Commercial and Game Fish Commissioners was devoted to problems of interest to the Biological Survey, which has been included in the membership of the council since April, 1937.

Some thirty papers made up the varied program which was arranged for the members of the American Fisheries Society. The papers were grouped under the general subjects of fish management, fish culture, research studies and miscellaneous topics. Nine papers on various technical problems of fishery research were read.

At the business sessions of the Fisheries Society, Fred J. Foster, regional director of Pacific coast and Rocky Mountain fish cultural stations, was elected president, and Deputy Commissioner Jackson was elected chairman of the committee on foreign relations. Other officers are: T. H. Langlois, first vice-president; James Brown, second vice-president; Seth Gordon, secretary-treasurer, and Kenneth E. Cobb, librarian. Division vice-presidents for the coming year are: Dr. H. H. Mackay, fish culture; Lauren R. Donaldson, aquatic biology and physics; Dr. H. J. Deason, commercial fishing; William C. Adams, protection and legislation; and C. R. Guterman, angling. Walter H. Chute was named chairman of the committee on common and scientific names of fishes.

IN HONOR OF GEORGE W. STEWART

A PORTRAIT of Dr. George W. Stewart, who will begin this autumn his thirtieth year of service as head of the department of physics at the State University of Iowa, was formally presented to the university at a banquet given in his honor on June 19.

The portrait, which was painted by William McCloy, of Drake University, was given by colleagues and former students. The presentation was made by Dr. Homer L. Dodge, dean of the Graduate College of the University of Oklahoma, one of fifty-two students who have received the degree of doctor of philosophy under Dr. Stewart. Professor Stewart spoke on "The Human Values of Physics."

Dr. Carl E. Seashore, research professor of psychology and dean emeritus of the Graduate College of the State University of Iowa, in accepting the portrait for the university, paid the following tribute to Dr. Stewart:

. . . eminent physicist through your significant contributions to basic problems in physical science, both pure and applied;

. . . recognized educator through your wise counsel and active leadership in graduate and undergraduate education, locally and nationally;

. . . great teacher by virtue of your sympathetic personal influence and comradeship with students and the fostering of progressive educational procedures;

. . . citizen of the world through your extensive travels and intimate associations with scholars at home and abroad and your ideals of the brotherhood of mankind;

. . . beloved citizen at home not only in your own name, but also through the noble civic spirit and service of your helpmate;

. . . gracious university host for colleagues and students, humble strangers and distinguished guests in your beautiful home;

. . . comrade with the seekers after truth, humbling yourself before the savants of all ages and projecting yourself into coming generations through your teachings and contributions to science;

. . . balanced personality in work and in play, in physical health, living in an atmosphere of intellectual, moral, social, artistic and religious pursuits, a whole man.

I bring you these sentiments of appreciation and appraisal in the name of the university.

Let the historian count this citation as a legend for the portrait now unveiled and to be appropriately associated with the projected murals, and thus let it mark a milestone at the present vantage ground in your distinguished career.

SCIENTIFIC NOTES AND NEWS

DR. FLOYD K. RICHTMYER, professor of physics and dean of the Graduate School of Cornell University, received the honorary degree of doctor of science at the commencement exercises of Lehigh University on June 14.

THE University of Toledo conferred at commencement the degree of doctor of science on Harry B. Meller, managing director of the Air Hygiene Foundation of the Mellon Institute, Pittsburgh, Pa.

C. F. HIRSHFELD, chief of research of the Detroit Edison Company, member and past chairman of the Engineers' Council for Professional Development, recently received the honorary degree of doctor of engineering from the University of Detroit, in recognition of his technical and scientific accomplishments in the field of engineering and in engineering education.

DR. FLORENCE B. SEIBERT, of the Henry Phipps Institute of the University of Pennsylvania, was presented with the Trudeau Medal "for outstanding research in the field of tuberculosis" at the Los Angeles meeting of the National Tuberculosis Association.

PROFESSOR W. H. HOFFMANN, of the Finlay Institute, Havana, has been awarded the Great Iron Medal of the Senckenberg Society of Frankfurt-on-Main in recognition of his research in tropical medicine.

Nature states that Professor Max Planck, of Berlin, who is an honorary fellow of the Royal Society of Edinburgh, was the guest at a dinner held in his honor in the rooms of the society on June 23. The president, Sir D'Arcy Wentworth Thompson, was in the chair.

PROFESSOR J. E. LITTLEWOOD, Rouse Ball professor of mathematics in the University of Cambridge, has been awarded the triennial award of the De Morgan Medal for 1938 of the London Mathematical Society.

DR. RUDOLF KREUTZ, of Cologne, has been awarded the Sudhoff Medal by the German Society of the History of Medicine.

THE London *Times* writes: "A tribute is paid in the eighty-ninth annual report of the Fitzwilliam Museum, Cambridge, to the thirty years of Sir Sydney Cockerell's directorship, during which 'benefactors have vied with one another in enriching the Museum.' Reference is also made to the retirement, coincident with that of Sir Sydney Cockerell, of a still older servant of the Fitzwilliam, W. E. Rider, who was appointed to the museum in 1884 and became principal assistant in 1910. A warm welcome is extended to the new director, L. C. G. Clarke."

AT the San Francisco meeting of the Vascular Section of the American Heart Association, the following officers were elected: *Chairman,* Dr. Irving S. Wright, New York; *Vice-chairman,* Dr. Irvine H. Page, Indianapolis; *Secretary,* Dr. Norman Freeman, Philadelphia.

PROFESSOR RICHARD KUHN, director of the Kaiser Wilhelm Institute for Medical Research at Heidelberg, has been elected president of the German Chemical Society.

PROFESSOR R. ALEXANDRI has been elected president and Professor C. Frugoni vice-president of the Royal Academy of Medicine of Rome.

THE following appointments have been made in anthropology at the University of Minnesota: Dr. Walter B. Cline, assistant-professor; Dr. David G. Mandelbaum, instructor; Dr. Lloyd A. Wilford, junior archeologist. Dr. Cline has been spending the past year in Europe preparing a book on the peoples of Arabia, Egypt and North Africa; Dr. Mandelbaum has been engaged in ethnographical work in India; Dr. Wilford has been exploring the archeology of Minnesota, and is engaged in that field this summer.

AT Indiana University, Professor S. C. Davisson has retired after forty-eight years of service in the department of mathematics; Dr. Emil Artin, who went to the University of Notre Dame from the University of Hamburg in the fall of 1937, has been appointed professor of mathematics; Dr. Agnes E. Wells, who has been dean of women in addition to teaching mathematics, has given up the work of dean to give full time to teaching as professor of mathematics; Professor K. P. Williams has been appointed chairman of the department.

THE following changes have been made in the department of physics at the University of Illinois: Professor F. W. Loomis, head of the department, has leave of absence during the first semester of 1938–39. During his absence Associate Professor P. Gerald Kruger will be acting head. Dr. M. Goldhaber, formerly at the Cavendish Laboratory, Cambridge, England, and Dr. J. R. Richardson, formerly national research fellow at the University of Michigan, have been appointed assistant professors of physics. Dr. L. J. Haworth, formerly Lalor fellow in physical chemistry at the Massachusetts Institute of Technology, and Dr. E. M. Lyman, formerly of the University of California, have been appointed associates, and Dr. D. W. Kerst, formerly with the General Electric X-Ray Corporation, has been appointed instructor.

AT the University of Nebraska, Dr. Erwin H. Barbour retired at the end of the academic year after serving for nearly forty-seven years as professor of paleontology and director of the museum. Dr. A. L. Lugn, associate professor, has been promoted to a full professorship of geology, and C. Bertrand Schultz has been made assistant director in charge of the museum. Mr. Schultz and Thompson M. Stout have been named instructors. Mr. Schultz will offer courses in vertebrate paleontology and direct research in that field. Mr. Stout will teach courses in general geology and earth science.

R. W. WARNER, professor of electrical engineering and head of that department at the University of Kansas, has been appointed to the corresponding position at the University of Texas. He will spend the summer in consulting work in industrial engineering at Kansas City.

DR. J. D. BOYD has been appointed to the university chair of anatomy at the London Hospital medical college. Since 1937 he has been university lecturer in anatomy in the University of Cambridge.

ENGLISH journals report that the Committee of the Privy Council for the Organization and Development of Agricultural Research has appointed the Earl of Radnor, lord warden of the Stanneries, chairman of the Lawes Agricultural Trust and a member of the Council of the Royal Agricultural Society of England, and Sir Joseph Barcroft, emeritus professor of physiology in the University of Cambridge and formerly Fullerian professor of physiology in the Royal Institution, to be members of the Agricultural Research Council in succession to Lord Richard Cavendish and Sir Frederick Gowland Hopkins. Sir Thomas Middleton is succeeding Lord Richard Cavendish as chairman of the council.

DR. G. ROBERT COATNEY, professor of biology at the State Teachers College at Peru, Nebr., has been appointed protozoologist of the U. S. Public Health Service.

THE American Ceramic Society has appointed Dr. Alexander Silverman, head of the department of chemistry in the University of Pittsburgh, as its representative on the Division of Chemistry and Chemical Technology of the National Research Council. Dr.

R. B. Sosman, of the Research Laboratory of the United States Steel Corporation, Kearny, N. J., has been appointed to the division of geology.

PROFESSOR OSKAR A. JOHANNSEN, who retired this year as head of the department of entomology at Cornell University, is spending July in England, Ireland and Scandinavia. In August he will attend the International Congress of Entomologists in Berlin.

PROFESSOR JAMES E. RICE, professor of poultry husbandry emeritus at the New York State Agricultural College at Cornell University, returned to Ithaca on July 6 from a tour of South and Central America in the interests of the seventh World Poultry Congress, to be held in Cleveland, Ohio, from July 28 to August 7, 1939. Professor Rice is chairman of the executive board. He plans to make a speaking tour on the West Coast, returning in September.

THE second Lerner Expedition of the American Museum of Natural History will leave for the swordfish grounds off Louisburg, Cape Breton Island, on August 6, to continue their study of the swordfish begun there in 1936. The members of the expedition will be: Michael Lerner, field associate; Miss Francesca La Monte, associate curator of ichthyology; G. Miles Conrad, assistant curator of comparative anatomy, and Ludwig Ferraglio, artist and preparator.

DR. A. C. SMITH returned to the New York Botanical Garden early in June after nine months of exploration in South America, during which he gathered specimens in the interior of British Guiana.

THE American Mathematical Society will meet in New York City from September 6 to 9. This is the semi-centennial celebration of the founding of the society. There will be addresses by Professor Ray C. Archibald on the history of the society, by Dean George David Birkhoff on a general review of mathematics during the fifty years and by Professors E. T. Bell, Griffith C. Evans, E. J. McShane, J. F. Ritt, J. L. Synge, T. Y. Thomas, Norbert Wiener and R. L. Wilder on work in their own fields. Excursions and other social events are planned.

THE Genetics Society of America will hold a summer meeting at Woods Hole on September 2 and 3. On Thursday evening, September 1, there will be given in the auditorium of the Marine Biological Laboratory a lecture by Dr. H. J. Muller. On Friday and Saturday mornings will be held formal sessions for the reading of papers. There will be demonstrations and exhibits on Friday afternoon and on Friday evening the usual boat trip and clam-bake.

THE Pennsylvania Academy of Science will hold its regular summer meeting at West Chester on August 12 and 13. Field trips have been arranged, particularly in botany and geology. Further information may be obtained from the secretary, Dr. V. Earl Light, Lebanon Valley College at Annville.

THE 1939 meeting of the Cotton States Branch, American Association of Economic Entomologists, will be held at Tampa, Florida, during the early spring. The dates and convention headquarters in Tampa will be selected at an early date. The Newell Entomological Society of the University of Florida is to serve as official host. Co-sponsors are the Florida Entomological Society, the Florida Institute of Agricultural Research, the Florida Horticultural Society, the Florida College of Agriculture, the Florida Experimental Station, the Florida State Plant Board and the Tampa Chamber of Commerce.

A GATHERING in celebration of the fiftieth anniversary of the foundation of the Educational Museum, Haslemere, England, and of the Haslemere Natural History Society, was held in the grounds of the museum on June 29. The speakers included Lord Winterton and Dr. John Ramsbottom, president of the Linnean Society and keeper of botany at the British Museum (Natural History). W. E. Muir, who presided, announced that an attempt was to be made this year to increase the endowment fund, which now stood at £5,600, by a further £5,000, which, with the amount raised from annual subscribers, would enable the museum to carry on its work.

THE German Surgical Society, to which most of the Austrian members of the International Society of Surgery belong, is reported by *The Lancet* to be at present in collaboration with the Viennese committee, making arrangements for the congress, which is to take place in Vienna from September 19 to 22. The following subjects will be discussed: Surgical treatment of hypertension, bone-grafts and surgical treatment of pulmonary cysts and tumors. Nearly 200 speakers have promised to take part. On the occasion of this congress the Messageries Maritimes are organizing a cruise, which will leave Marseilles on September 4 and will give surgeons the opportunity to attend operative demonstrations at Naples, Athens, Istanbul, Odessa, Bucharest and Budapest.

IT is reported that the Turkish Government will establish a School of Medicine at the University of Angora. The plans provide for an expenditure of $6,800,000.

THE second trailer expedition of the department of mammals of the American Museum of Natural History left on July 8 for New Mexico, to collect large and small mammals such as weasels, squirrels, marmots, deer and bears. Collecting will be done on the 300,000-acre Philmont Ranch owned by Waite Phil-

lips, near Cimarron, N. M., and in the northeastern section, where the foothills of the Rockies rise from 6,000 to 12,000 feet. The expedition includes: Dr. John E. Hill, associate curator, and William Buchanan, assistant in mammalogy. They will be joined later by Robert E. McConnell, a trustee of the museum, and Harold B. Clark, who last summer led an Alaskan expedition for the museum.

DISCUSSION

OXYGEN-POOR WATERS OF THE CHESAPEAKE BAY

STUDIES on the physical and chemical properties of Chesapeake Bay waters during the summer of 1936 gave evidence of a definite oxygen-poor layer at the bottom in the deeper regions, and data from subsequent series of water samples have proved the existence of that layer and have furnished interesting information concerning its vertical and horizontal extent. Water samples for these studies have been secured at the stations shown by the numbered dots on the accompanying chart (Fig. 1), and sampling is now being

FIG. 1. Locations of principal sampling stations (numbered points) in Chesapeake Bay and the Patuxent River.

continued at those stations, with the aid of a grant from the American Philosophical Society. Three stations are in the bay, opposite the mouth of the Patuxent River (about 38° 18′ N. lat., 76° 25′ W. long.), and others are located at various places in the tidewater reaches of the river.

A clearly defined oxygen stratification appears to prevail in the bay from about June 1 to about October 1, with very low oxygen concentration in the bottom waters. This is accompanied by an equally pronounced salinity stratification of opposite gradient, with high salt concentration at the bottom. The oxygen concentration of the surface waters varies around 6 cc per liter (104 per cent. of total saturation), while at depths of 8 to 10 meters the oxygen content is frequently as low as 2 cc per liter (35 per cent. of total saturation). Below a depth of 12 meters, the concentration is usually under 1 cc per liter (17 per cent. saturated), and deep samples are often found to contain no measurable oxygen. The top of the oxygen-poor layer usually occurs at a depth of about 9 meters.

The summer range of oxygen concentration from the surface water to the oxygen-poor layer below is narrower above the river mouth than in the bay, and it diminishes rapidly in the upstream direction as is shown by the dark area of Fig. 2. Also, the stability

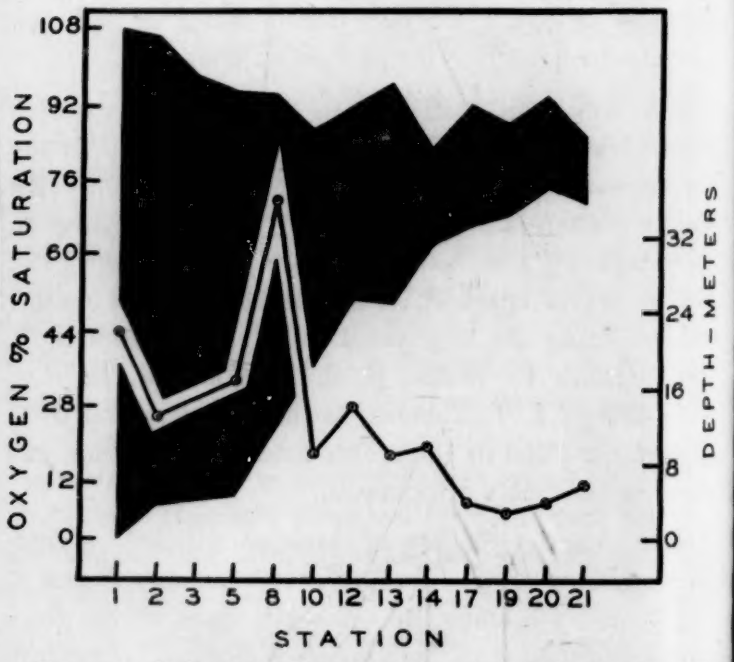

FIG. 2. Ordinates of upper margin of dark area are summer O_2 contents near surface and those of lower margin are corresponding O_2 contents near bottom, at stations numbered as in Fig. 1; ordinates of line graph show depths of water at the several stations.

of the water layers decreases in like manner. Of course, any influences that produce vertical mixing—such as seasonal temperature changes or local tidal

and topographic differences—may modify or destroy stratification. It was found in 1937 that instability of the water strata, due to mixing, began in the latter part of September at the upper river stations and slowly progressed downstream toward the deeper waters of the bay, where effective mixing did not begin until late October. The stratification of winter, which has not yet been studied seriously, seems to be notably different from that of the summer season.

It appears that oxygen stratification in the Chesapeake Bay differs markedly from that prevailing in the Western Basin of the North Atlantic. Seiwell's[1] extensive investigations have shown that in that ocean region, where salinity stratification is not well developed, there is an oxygen-poor layer at intermediate depths, characterizezd by oxygen contents less than 60 per cent. of total saturation. That layer lies between a surface layer and a bottom layer, both of which are relatively rich in oxygen. On the other hand, in the Chesapeake Bay the surface stratum, which has low salt content and high oxygen content, is underlaid, at least in summer, by a bottom layer of much higher salinity and exceedingly low oxygen concentration. Seiwell's results, together with those of other students of Atlantic and Pacific waters, have contributed much to our general knowledge of marine environments, and further study of the various factors that control bathymetric oxygen variations should lead to a better understanding of many fundamental problems in oceanography and its diverse applications in the fishery industries.

In the preparation of this paper, valuable advice and criticism have been received from Professor Burton E. Livingston, of the Johns Hopkins University, and from Professor R. V. Truitt, of the University of Maryland.

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THE EFFECT OF ARSENIC ON THE TOXICITY OF SELENIFEROUS GRAINS

DURING investigations on the "alkali disease" or selenium poisoning and investigations on the comparative toxicities of several elements including selenium, tellurium, arsenic, vanadium, nickel, tungsten and molybdenum it was observed that, at the concentrations used, selenium was the only one of the elements to cause severe liver pathology[1,2,3,4,5] in the rat.

More recent experiments on the combined toxicities of selenium in combination with the above mentioned elements have revealed that the feeding of arsenic along with seleniferous grains prevents the characteristic symptoms of selenium poisoning in rats. The addition of 5 ppm of arsenic as sodium arsenite to the drinking water has given full protection against liver damage caused by 15 ppm of selenium in the form of seleniferous wheat. Two and one half ppm of arsenic gave only partial protection. The animals receiving 5 ppm of arsenic in their drinking water and 15 ppm of selenium in their feed also appear to be free from the other characteristic symptoms of selenium poisoning. Experiments also indicate that arsenic is effective in preventing liver damage and the general toxic effects of inorganic selenium as well as organic selenium (selenium occurring naturally in grains).

The feeding of arsenic to livestock to prevent selenium poisoning is not recommended on the basis of these results but since arsenic is effective it is hoped that some other elements or compounds which are in themselves non-toxic will be effective. Experiments are underway, and certain compounds have given promising results. Experiments with larger animals are also underway. A more detailed report is in preparation.

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"ANOMIA" PECTEN LINNAEUS

LINNAEUS, in the tenth edition of "Systema Naturae," 1758, p. 702, describes a fossil shell, *Anomia pecten,* in these words: "A. testa semi-orbiculata depressa multistrata; valvula altera plana (List. Angl. 243., t. 9, f. 49). Testa inferne s. margine cardinis linea recta s. transversa." No locality was given, but a specimen is contained in his cabinet at the Linnaean Society, London.

Lister's figure, cited by Linnaeus, is of a specimen "ex fodinis carbonum Fossilium juxta Hallifax," and is quite recognizable as *Pterinopecten papyraceus* (J. Sowerby, 1822) known to occur in the Halifax Hard Marine Band in the Coal Measures. The above description could be held to apply to this shell. By a strict application of the rules of nomenclature J. Sowerby's specific name would appear to be invalidated by Linnaeus's previously described species.

On the other hand, there is no doubt that Linnaeus had before him Swedish Silurian brachiopod shells long known as *"Strophomena" pecten* (Linn.). Knowledge

[1] Papers in Physical Oceanography and Meteorology, Vol. III, No. 1, 1934, and Vol. V, No. 3, 1937, Cambridge, Mass.

[1] K. W. Franke and V. R. Potter, *Jour. Nutrition,* 10: 213–221, 1935.

[2] H. E. Munsell, G. M. DeVaney and M. H. Kennedy, U. S. D. A. *Tech. Bull.* 534, 1936.

[3] K. W. Franke and A. L. Moxon, *Jour. Pharm. and Expt'l. Ther.,* 61: 89–102, 1937.

[4] A. L. Moxon, S. Dak. Agric. Expt. Station *Bulletin* No. 311, 1937.

[5] Unpublished data—this laboratory.

of the typical form was spread by personal contact among Swedish paleontologists, and the first figured specimen of *"S" pecten* (Dalman, Kogl. vet. Akad. Handl. for 1827, p. 110, 1828) is probably conspecific with the specimen still preserved in the Linnaean cabinet.

This confusion seems to arise from a difference in method. Linnaeus presumably only intended to show the general appearance of his shell to other workers, not to establish a type specimen.

Since *Pterinopecten papyraceus* is a common shell, cited in European literature for over 100 years, strict interpretation of the rules would lead to confusion. Therefore I am applying to the International Committee for Zoological Nomenclature for a suspension of the rules in this case, so that the name *"S." pecten* (Linn.) can be retained for the Silurian brachiopod.

Other of the Linnaean species are similarly referred to figures which do not represent the species in its modern interpretation (*e.g.,* such a common fossil as *Atrypa reticularis*) and, if the rules are suspended in the present case, a precedent will have been set up for the retention of those Linnaean species at present doubtful.

If the rules are suspended and *"S." pecten* (Linn.) is retained, I propose to figure and describe the specimen of *"Anomia" pecten* in the Linnaean cabinet as the neotype.

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SOME PLEISTOCENE MAMMALS FROM WARREN COUNTY, VIRGINIA

MR. T. M. MUSSAEUS, president of the Limeton Lime Company at Limeton, about six miles south of Front Royal, Warren County, Virginia, informed us that in recent quarrying operations a fissure filled with red clay containing bones had been opened up. Unfortunately most of the material had been discarded before he learned of the find, but he secured a few teeth, which were brought to Washington and identified by Mr. Charles W. Gilmore. The animals represented were a lion (*Felix atrox*), a tapir (*Tapirus,* sp.) and a bear (*Euarctos,* sp.). In view of the very few notices of Pleistocene mammals from the caves of Virginia this occurrence seems worth recording.

AUSTIN H. CLARK

U. S. NATIONAL MUSEUM

SOCIETIES AND MEETINGS

THE OHIO ACADEMY OF SCIENCE

THE forty-eighth annual meeting of the Ohio Academy of Science was held at the College of Wooster, Wooster, Ohio, on May 6 and 7 under the presidency of Charles G. Shatzer, of Wittenberg College, Springfield, Ohio, and was by common consent one of the very best meetings of the academy ever held. The setting for the meeting was practically perfect, the College of Wooster, ably assisted by the Ohio Agricultural Experiment Station, having made every possible effort to anticipate and provide for the requirements, comfort and pleasure of all visiting scientists. The local committee on arrangements under the fine leadership of Professor Karl Ver Steeg was unusually efficient in caring for the many details incident to such a meeting.

The business portion of the meeting consisted of two short sessions, at which the following items of general interest were transacted, *viz.:*

(1) The academy authorized the formation of a new section to be known as the Section of Mathematics.

(2) The academy authorized the appointment of a special committee to cooperate with the Ohio director of education in an intensive study of the needs and requirements of science teachers in the public schools.

(3) It was voted to meet with the University of Cincinnati next year.

(4) The academy went on record as favoring a council form of government and authorized the appointment of a committee to study the constitution and by-laws and to suggest such changes as might be necessary to put such a form into operation at the next annual meeting.

(5) Passed a resolution approving the stand taken by the Western Society of Naturalists last December in opposition to the so-called "State Humane Pound Law" of California, the purport of which is to curtail animal experimentation by students of biology and medicine.

(6) The following five members were advanced to fellows in the academy: Dr. Fred A. Carlson, Ohio State University; Dr. Raymond A. Dobbins, Ohio Northern University; Dr. Robert A. Hefner, Miami University; Dr. Walter C. McNelly, Miami University; and Dr. John J. Wolford, Miami University.

(7) Sixty-one new members were elected, giving the academy at this time a membership slightly over five hundred.

(8) In preparation for the fiftieth anniversary in 1940 of the academy's organization, chairmen for the following committees were elected: *Publicity,* Edward S. Thomas; *Program,* Clarence H. Kennedy; *Speakers,* Frank J. Wright; *Historical Statistics and Lists,* Samuel Renshaw.

(9) The academy went on record as strongly favoring the efforts being made by the committee on conservation to secure lake shore lands for park purposes.

The academy held one general scientific session at which Dr. Paul Popenoe, of the Institute of Family Relations at Los Angeles, Calif., gave a very fine address on "Heredity and Education," and the state director of education, Mr. E. N. Dietrich, spoke on the "Training of Science Teachers."

For real zeal and enthusiasm, the annual dinner on Friday, May 6, was the climax. This fine gathering was presided over in a most delightful manner by Professor Karl Ver Steeg, of the College of Wooster, who had rendered such fine service as chairman of the local committee. Professor Ver Steeg proved himself a real past master as a toastmaster. More than 300 persons sat down to dinner and enjoyed both a physical and an intellectual feast. President Charles F. Wishart, of the College of Wooster, and Director Edmund Secrest, of the Ohio Agricultural Experiment Station, extended a cordial welcome to the visiting scientists, to which Dr. Dayton C. Miller, of the Case School of Applied Science, responded most appropriately. Then followed the real event of the evening, namely, the presidential address by President Charles G. Shatzer on "When Are We Scientific?" He gave the listening scientists much to think about from a rather new and novel point of view. After the presidential address Dr. George B. Barbour, of the University of Cincinnati, showed "Vesuvius in Eruption" by the use of colored films.

The eight sectional programs were replete with interesting papers and the sectional meetings well attended. Space will not permit even the listing of these papers. Several excursions were provided to points of interest, notably to the arboretum at the Experiment Station.

The following officers were elected for the coming year:

President: Claude E. O'Neal; *Vice-Presidents: Zoology,* Robert A. Hefner; *Botany,* Paul B. Sears; *Geology,* W. Storrs Cole; *Medical sciences,* Dr. L. F. Edwards; *Psychology,* James R. Patrick; *Physics* and *astronomy,* Leon E. Smith; *Geography,* Fred A. Carlson; *Chemistry,* Harvey V. Moyer; *Secretary:* William H. Alexander; *Treasurer:* Eugene Van Cleef.

WILLIAM H. ALEXANDER,
Secretary

THE NEW HAMPSHIRE ACADEMY OF SCIENCE

THE twentieth annual meeting of the New Hampshire Academy of Science was held on May 27 and 28 at The Tavern, Laconia. Dr. E. J. Roberts was chairman of the local committee. At the Friday evening session Professor J. W. Goldthwait summarized his studies on the glacial geology of central New Hampshire in a paper "Was there a Glacial Lake Winnepesaukee?", and Professor G. W. White, who was the academy's representative at the seventeenth International Geological Congress in the U. S. S. R., gave an illustrated report on the Geological Congress excursions to Caucasia and Armenia and to Novaya Zemlya.

Papers by members were read at the Saturday morning session. At the Saturday afternoon session following the business meeting, the presidential address, "The Advantages of a Long Hard Winter," was given by Professor Karl W. Woodward, of the University of New Hampshire.

At the business meeting it was voted to award the grant-in-aid for the current year from the American Association for the Advancement of Science to Mr. Clayton E. Fisher, of Colby Junior College, for assistance in continuing "An Investigation of Some Derivatives of Phenanthrene." The committee on conservation reported that its studies of "natural association areas" show that a fair number of such areas are already in public ownership, and the committee was authorized to confer with public ownership bodies on the proper setting aside of "association" and "type" areas. The publications committee, Mr. Frank Foster, Claremont, chairman, was authorized to recommend further publications and oversee their issuance, subject to approval by the executive council.

The following officers were elected for 1938–39: *President,* Dr. Henry I. Baldwin, State Forestry Department; *Vice-President,* Professor George W. White, University of New Hampshire; *Secretary-Treasurer,* Professor W. W. Ballard, Dartmouth College; *Member Executive Council,* Professor Karl W. Woodward, University of New Hampshire; *Councilor to the American Association for the Advancement of Science,* Professor George F. Potter, University of New Hampshire.

GEORGE W. WHITE,
Retiring Secretary

SPECIAL ARTICLES

ELECTROPHORESIS EXPERIMENTS WITH EGG ALBUMINS AND HEMOGLOBINS

THE species specificity of proteins, readily demonstrable serologically and indeed detected by this means, has been investigated only to a small extent by chemical and physicochemical methods, with the exception of studies on hemoglobin, *e.g.,* by crystallographic measurements. The possibility of distinguishing be-

tween proteins with the aid of the very valuable electrophoretic technique of Tiselius[1] suggested the application of this method for the study of species differences in proteins. In this way some information might possibly be obtained on the chemical basis of these differences, since the electrochemical properties of proteins depend upon the number and nature of their acidic and basic amino acids. In particular, the question arises whether variations in isoelectric points and mobility parallel the serological relationships in the two cases, possibly not equivalent in this respect, namely, proteins of a certain type derived from various species (as serum albumins) and, on the other hand, various types of proteins occurring in a single species.

TABLE I

ELECTROPHORETIC MOBILITIES OF 0.5 PER CENT. EGG ALBUMINS IN 0.02 NORMAL SODIUM ACETATE BUFFER AT pH 5.20. TEMPERATURE 0.0° C.

Egg albumins	$u \times 10^{-5}$
Chicken	−3.53
"	−3.56
Guinea hen	−3.76
Turkey	−3.53
Duck	−4.27
Goose	−4.60

Some preliminary experiments undertaken along this line were carried out with egg albumins of chicken, turkey, guinea hen, duck and goose, the first three having been thrice recrystallized and the remaining two separated by ammonium sulfate with the addition of acid. The mobilities, u, are recorded in Table I. The schlieren photographs, taken at 30-minute intervals both before and after the reversal of the current, of a typical experiment with guinea hen egg albumin are shown in Fig. 1.

TABLE II

ELECTROPHORETIC MOBILITIES OF THE COMPONENTS OF MIXTURES OF EGG ALBUMINS AT DIFFERENT pH VALUES AND CONSTANT IONIC STRENGTH 0.02. TEMPERATURE 0.0° C.

Protein 1	Protein 2	Buffer	pH	$u_1 \times 10^{-5}$	$u_2 \times 10^{-5}$
0.5 per cent. duck	0.5 per cent. guinea hen	Acetate	5.21	−4.34	−3.77
" " " turkey	" " " "	"	5.21		−3.49
" " " "	" " " "	Phosphate	7.18		−9.81
" " " chicken	" " " "	Acetate	3.48	+5.57	
" " " "	" " " "	"	5.16		−3.73
" " " "	" " " "	Phosphate	7.19		−9.86

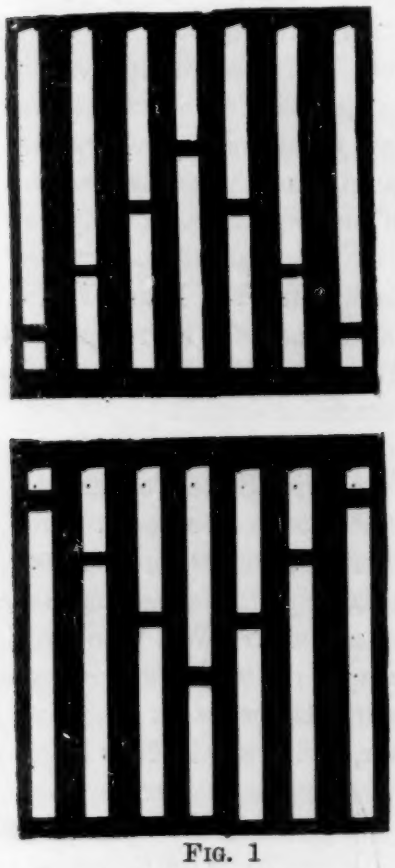

FIG. 1

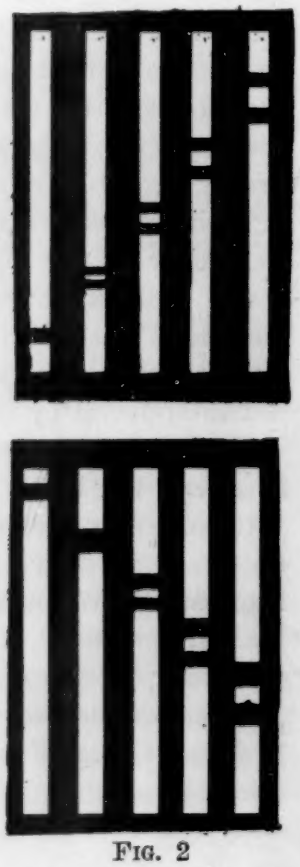

FIG. 2

FIG. 1. Schlieren photographs of the anode (upper) and cathode (lower) sides taken at 30 minute intervals during the electrophoresis of egg albumin (guinea hen). The three last exposures (right) were made after reversal of the current.

FIG. 2. Schlieren photographs of the electrophoresis of a mixture of guinea hen and duck egg albumins.

Confirmation and extension of the data of Table I were obtained from measurements on the mixtures reported in Table II.

In only the mixture of duck and guinea hen egg albumins were the mobilities of the components sufficiently different to permit resolution into two bands, as shown in Fig. 2, which is the schlieren photograph of this mixture. In all the other mixtures, however, the boundaries were more diffuse than for the pure components and gave indications that prolonged electrolysis or increased resolving power of the schlieren apparatus would make visible the very slight separation of the components to be expected from the data of Table I. Considering the differences in total protein concentration the data of Table II at pH 5.2 are in satisfactory agreement with those of Table I.

It appears that several ovalbumins—chicken, guinea hen, turkey, belonging to three families, but to the same order (Galliformes)—which, although related, are easily distinguishable by serological precipitin reactions, exhibit close resemblance in the electrophoresis experiment. Consequently, there must exist a great number of proteins of a given type which are very similar electrophoretically. The albumins from duck and goose eggs, both birds belonging to the Order Anseriformes, are seen to form a second group with mobilities definitely different from the others, which

[1] Arne Tiselius, *Trans. Faraday Soc.*, 33: 524, 1937.

is in agreement with the zoological (and serological) relationships of these birds.

Another type of protein examined was hemoglobin from dog, rabbit, guinea pig, sheep and horse used as solutions obtained by laking washed blood cells. The measurements of these solutions are recorded in Table III. The hemoglobin boundaries were, in general, more diffuse than those of egg albumin.

TABLE III

ELECTROPHORETIC MOBILITIES OF 0.5 PER CENT. HEMOGLOBIN SOLUTIONS IN A PHOSPHATE BUFFER OF pH 7.95 AND IONIC STRENGTH 0.1. TEMPERATURE 0.0° C.

	$u \times 10^{-5}$
Hemoglobins	
Rabbit	−2.15
Sheep	−2.3
Dog	−2.4
Horse	−3.0
Guinea pig	−3.0
Chicken*	−1.6

* The boundaries with both laked blood and crystallized hemoglobin were very diffuse. A second and slower band of unknown significance appeared in the cathode side of the U-tube. This band was sharp and distorted.

Some of the hemoglobins behaved very similarly when subjected to cataphoresis (sheep, dog, rabbit and horse, guinea pig) despite the fact that the animals represent different orders and are, serologically, almost unrelated. The close agreement of the mobilities of dog and sheep hemoglobins is in accord with values by Michaelis[2] for the isoelectric points of these proteins from dog and sheep. It would be desirable to extend the determinations of mobilities and isoelectric points systematically to hemoglobins and other proteins from a large number of species.

The mobility differences of the hemoglobins of Table III, although not inappreciable, are not as striking as is the rather wide disparity in solubilities of various hemoglobins. It may be presumed that the observed likenesses in electrochemical behavior of serologically distinct hemoglobins of distant species point to a similarity in their content of acid and basic groupings, and the same question is to be considered for the species variations of other types of proteins. The very pronounced serological differences would then depend on structural features of the molecule other than those which determine the charge. Here, reference may be made to the analytical results of Block,[3] and Vickery and White,[4] discussed by Bergmann and Niemann[5] in the light of their theory of protein structure, from which the hemoglobins of the horse, sheep, cattle and dog all contain the same amounts of the basic amino acids, arginine, histidine and lysine, whereas there are differences in the cysteine and total sulfur content.

[2] L. Michaelis and Z. Bien, *Biochem. Zschr.*, 67: 198, 1914.

[3] R. J. Block, *Jour. Biol. Chem.*, 105: 663, 1934.

[4] H. B. Vickery and A. White, *Proc. Soc. Exp. Biol. and Med.*, 31: 6, 1933.

[5] M. Bergmann and C. Niemann, *Jour. Biol. Chem.*, 118: 301, 1937.

Further accurate figures on other "neutral" (monoamino monocarboxylic) and the dicarboxylic amino acids will be of particular interest. In connection with the foregoing mention should be made that hemocyanins of various species, even of two species of snails, appear to have distinctly different mobility slopes, according to measurements reported by Svedberg.[6]

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THE DETERMINATION OF SULFANILAMIDE

THE method recently proposed for the determination of sulfanilamide in blood and urine[1,2,3] has been widely used both in experimental work and in controlling the administration of the drug to patients. The purpose of the present note is to call attention to certain improvements in the method which have been in use for the past two months in this laboratory. By destroying the excess nitrous acid after diazotization and buffering the solution before coupling with dimethyl-α-naphthylamine more rapid color development and more permanent colors are obtained. In addition, it has been found that in the presence of sodium chloride and certain other substances, the excess nitrous acid destroys some of the azo dye formed. This is entirely avoided by destruction of the excess nitrous acid after diazotization is complete.

The revised procedure is as follows. To 10 cc of the blood filtrate or acidified standard solution, 1 cc of a 0.1 per cent. freshly prepared solution of sodium nitrite is added. After 3 minutes standing, 1 cc of a 1 M sodium dihydrogen phosphate containing 0.5 per cent. of ammonium sulfamate[4] ($NaH_2PO_4 \cdot H_2O$, 13.8 gms; ammonium sulfamate, 0.5 gm; water 100 cc) is added and after 2 minutes standing, 5 cc of the alcoholic solution of dimethyl-α-naphthylamine are added. After 10 minutes, the solutions are compared in a colorimeter. By buffering, the pH of the final colored solution is maintained at 1.7 to 1.8. It has been found that pH changes from 1.0 to 2.0 do not influence the diazotization but do affect the rate of coupling.

[6] T. Svedberg, *Ind. and Eng. Chem.*, Analytical Ed. 10: 113, 1938.

[1] E. K. Marshall, Jr., Kendall Emerson, Jr., and W. C. Cutting, *Jour. Am. Med. Asn.*, 108: 953, 1937.

[2] E. K. Marshall, Jr., *Proceedings, Soc. Exp. Biol. and Med.*, 36: 422, 1937.

[3] E. K. Marshall, Jr., *Jour. Biol. Chem.*, 122: 263, 1937.

[4] We are indebted to Dr. H. A. Lubs, of E. I. du Pont de Nemours and Company, for suggesting the use of sulfamic acid to destroy nitrous acid, and for furnishing us with this substance. Ammonium sulfamate can be obtained from LaMotte Chemical Products Company of Baltimore.

With the removal of excess nitrous acid, sodium chloride does not appear to influence the determination. Hence, acetyl-sulfanilamide can be just as readily determined in trichloroacetic acid filtrates as in those obtained by the use of p-toluenesulfonic acid by the following procedure.

One volume of a 15 per cent. solution of trichloroacetic acid is used for each 4 volumes of diluted blood. The free sulfanilamide is determined in the filtrate as described above. To determine the total, 10 cc of filtrate are treated with 1 cc of 2 N hydrochloric acid, heated in a boiling water bath for one hour, cooled and the volume adjusted to 10 cc. The subsequent procedure is as above, except that in place of the 1 M phosphate buffer, a 2 M phosphate buffer containing 0.5 per cent. of ammonium sulfamate is used. The standard solution of sulfanilamide (containing 18 cc of 15 per cent. trichloroacetic acid per 100 cc) is treated as the standard used for determining free sulfanilamide.

For determination of both free or conjugated sulfanilamide in blood, we now employ a 1:20 dilution instead of a 1:10 when an ordinary type of colorimeter is used. With a photoelectric colorimeter greater dilutions of blood can be advantageously used.

Since the disturbing effect of sodium chloride is avoided by the destruction of excess nitrous acid with sulfamate, satisfactory determinations can be made in lower dilutions of urine than previously.

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INDUCING "DORMANCY" IN POTATO TUBERS WITH POTASSIUM NAPHTHALENEACETATE AND BREAKING IT WITH ETHYLENE CHLOROHYDRIN[1]

POTASSIUM naphthaleneacetate inhibits the growth of the buds of non-dormant potato tubers (*Solanum tuberosum* L.) and the pieces treated with it behave like pieces of dormant or freshly-harvested potato tubers inasmuch as they do not grow for a month or more after planting. The inhibiting action of auxin-like substances on the growth of axillary buds is well known.[2] If the potato pieces are treated with ethylene chlorohydrin after treatment with potassium naphthaleneacetate they are stimulated to grow much before similar pieces not treated with ethylene chlorohydrin. The results are like those obtained by treating dormant tubers with ethylene chlorohydrin.

[1] Herman Frasch Foundation for Research in Agricultural Chemistry, Paper No. 167.

[2] K. V. Thimann and F. Skoog, *Proc. Roy. Soc. B*, 114: 317–339, 1934.

Pieces from tubers of the Green Mountain variety were used. These had been stored all winter and untreated pieces showed emergence of sprouts about 12 days after planting. The tubers were cut into approximately cubical pieces weighing about 20 g each, with the skin at the top and one bud in the center of the upper side. They were washed, dried with cheesecloth and placed, bud up, in open petri dishes containing a solution of potassium naphthaleneacetate, 100 mg per liter, so that they were about two thirds immersed in the solution. After standing in the solution four days at 10° C., the pieces were planted in soil for eight days. They were then dug up, washed and the callus cut off in a thin layer. Some of the pieces were treated with ethylene chlorohydrin by the dip method of Denny.[3] They were dipped into a solution of 25 cc of 40 per cent. ethylene chlorohydrin per liter of water and after draining off the excess solution, were stored in a closed container for 24 hours. Control pieces were dipped in water. The pieces were then planted. Ten days later 20 out of 24 treated pieces showed sprouts above ground, while no sprouts had started on the 24 control pieces treated originally with potassium naphthaleneacetate but not subsequently treated with ethylene chlorohydrin.

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[3] F. E. Denny, *Contrib. Boyce Thompson Inst.*, 1: 59–66, 1926.

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